A woman with her chaya bush in Chiquimula, Guatemala. Credit G. Meldrum/Bioversity International

Underutilized crops in the production systems, livelihoods and diets of farmers in Chiquimula, Guatemala

Baseline results from the programme "Linking agrobiodiversity value chains, climate adaptation and nutrition: Empowering the poor to manage risk"

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Contributors

This analysis and report were prepared in the context of the Project “Linking agrobiodiversity value chains, climate adaptation and nutrition: Empowering the poor to manage risk” supported by the International Fund for Agricultural Development (IFAD), the European Commission, and the CGIAR Research Programmes on Climate Change, Agriculture and Food Security (CCAFS) and Agriculture for Nutrition and Health (A4NH) from 2015-2018. The analysis has been made possible by the efforts of the Project coordination and implementation teams from Bioversity International and Universidad del Valle de Guatemala (UVG), as well as many contributors to the design of the survey tools.

Project coordinators

Stefano Padulosi (Global Project Coordinator, Bioversity International)

Silvana Maselli (Project Coordinator for Guatemala, UVG)

Implementation and field teams

Rolando Cifuentes, Emerson Herrera, Maria Fernanda Maldonado, Nidia Pereira, Brenda Rodas, Valerie Corado, Karla Bojorque, Jacqueline de León, and Byron Fuentes (UVG)

Adolfo Vásquez and Diego Agustín (Mancomunidad Copan´chortí)

Jacob Van Etten and Brandon Madriz Araya (Bioversity International)

Analysis and report

Gennifer Meldrum, Gaia Lochetti, and Gaia Gullotta (Bioversity International)

Advisors

Gina Kennedy, Jessica Raneri, and Elisabetta Gotor (Bioversity International)

The questionnaires were designed in a consultative process starting with working groups on best indicators at the Project launch conference, followed by rounds of comments on the questionnaires by the Project coordination team and conference participants (see Padulosi et al 2016). The questionnaire was translated and adapted to Open Data Kit (ODK) format for implementation Guatemala to follow a similar format as other ongoing Bioversity International projects in the Mesoamerica region.

Citation

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Abbreviations

A4NH	The CGIAR Research Programme on Agriculture for Nutrition and Health
CCAFS	The CGIAR Research Programme on Climate Change, Agriculture and Food Security
CGIAR	Consultative Group for International Agricultural Research
COCODES	Comunal Development Committees
Excl	Excluding
GPS	Global Positioning System
Ha	Hectares
HDDS	Household dietary diversity score
IFAD	International Fund for Agricultural Development
Incl	Including
MAHFP	Months of adequate household food provisioning
NGO	Non-governmental organization
ODK	Open data kit
PPI	Progress Out of Poverty Index
Project	The initiative “Linking agrobiodiversity value chains, climate adaptation and nutrition: Empowering the poor to manage risk” supported by IFAD and the European Union from 2015-2018
USA	United States of America
UVG	Universidad del Valle de Guatemala

Executive summary

The programme “Linking agrobiodiversity value chains, climate adaptation and nutrition: Empowering the poor to manage risk” funded by IFAD and the European Commission from 2015 to 2018 aims to strengthen the capacities of farmers to manage risks associated with climate change, poor nutrition status, and economic disempowerment through agrobiodiversity-based solutions. Enhancing productivity and promoting use of nutritious and climate-hardy underutilized species is the core of the initiative, which is focusing on chaya (*Cnidoscolus aconitifolius*) and tepary bean (*Phaseolus acutifolius*) in Guatemala. Chaya is a native perennial shrub that produces highly nutritious leaves all year round. This underutilized crop can enhance nutrition of communities in the dry corridor of Guatemala and provide an income opportunity for small producers. A holistic approach addressing multiple bottlenecks in supply and demand is being applied for chaya in the Project, engaging consultation and participation of multiple stakeholders to ensure value chain interventions are pro-poor and gender-sensitive. Tepary bean is native to dry regions of northern Mexico and the southern USA and has been grown throughout the Mesoamerican region. It is currently almost unknown in Guatemala. Thanks to its high drought tolerance, tepary bean could help adapt farming systems to climate change, which is challenging production of common bean (*Phaseolus vulgaris*)—the fundamental staple of Guatemelan diets alongside maize (*Zea mays*).

This baseline household assessment provided an overview of the production and livelihood systems of 88 households in three communities in Chiquimula district of Guatemala. The results reveal useful insights to guide project actions and provides a snapshot of the communities prior to intervention that can help document the impact of the Project. The survey documented the level of cultivation, commercialization, and consumption of chaya and revealed some clues to how chaya and tepary bean can contribute to improving food security, nutrition, and incomes in the surveyed communities. Chaya was cultivated by about a quarter of households in the surveyed villages. It was predominantly being used for household consumption. Aside from limited trading within the community, chaya was not being marketed. Low consumption of vegetables revealed in the 24-hour diet recall shows that chaya could contribute to more balanced diets, especially in the lean season when there is less frequent consumption of vegetables. Tepary bean was not cultivated or consumed in the surveyed communities but common bean was grown by the majority of households and was an income source for several households. No other pulses were grown in the community and there was a low level of meat consumption, meaning there was high reliance on common bean for dietary protein. The greater drought tolerance of tepary bean means it could help ensure a more stable and resilient pulse production for the communities and, with attention to value chain development, could also provide an income source.

This analysis is a beginning point for more detailed analysis on the value chains of chaya and tepary bean, the relevance of these species in the livelihoods of men and women in Guatemala, and their adaptation to the threats of climate change. Further work on documenting the value chain of chaya and the seasonal calendars of local fruits, vegetables and pulses will be carried out in the Project, along with promotional activities for enhancing the contributions of these crops to farmers’ livelihoods.

Introduction

Guatemala faces serious issues of poverty and hunger (Global Index for Hunger, IFPRI 2015). Around half of children under five are affected by chronic malnutrition (49.8%), while 1.4% are affected by acute malnutrition (ENSMI-2008/09). Thirty five percent of children under five years of age are deficient in zinc, 12.9% in vitamin B12 and 26.3% in iron (ENMICRON 2009/10). At the same time, there are cases of overweight in Guatemala, which affects 5.6% of children under five years of age (Encuesta Nacional de Salud Materno Infantil 2002). Some regions are more affected by these burdens. Highest rates of extreme poverty are seen in the departments of Alta Verapaz, Baja Verapaz, Chiquimula, Izabel, Sololà, Suchitepequez, Totonicapan, and Zacapa where more than 20% of the population suffers extreme poverty (INE 2011). Chronic malnutrition is higher in rural areas than urban areas and is high to very high (60-83%) in the departments of Chiquimula, Quiche, Solola, Totonicapan, and Hehuetenango (ENSMI-2008/09). The prevalence of chronic malnutrition in children under five years of age is higher among subsistence farmers, indigenous peoples, and those with uneducated mothers (ENSMI-2008/09, UNICEF, ICEFI & SUECIA 2013).

Seasonal famine is common in Guatemala—especially in the dry corridor. The agricultural calendar is marked by seasonal weather events. The first rainy season from May to June precedes a heat wave and drought in July and August referred to as the 'canicula', which is followed by a second rainy period from September to October (FEWS NET 2013). Malnutrition cases among children less than five years of age occur in conjunction with exhausted cereal reserves (April to August), the end of the coffee, sugar, and cardamom harvest that provides temporary labor (November to March), and during the rainy season (May to September), which is associated with water sanitation issues and infectious disease. Changes have been occurring in the climate and seasonal calendar in recent years. The beginning and the end of the rainy seasons have been shifting, making it difficult to predict when rain will come. Natural climate variability from phenomena such as El Niño and La Niña is being amplified, bringing more severe droughts. The expected future scenario (by 2100), will involve an increase of temperature from 2-6ºC and a decrease in rainfall between 10-20% (IPCC 2014). Increasing uncertainty and severity of the climate are bringing greater risk for food security.

Rich agricultural biodiversity is a basket of solutions

Guatemala is a global hotspot for biodiversity. It is a mountainous and highly forested (37%) country characterized by high rates of species endemism (13%) (CBD 2015). In addition to rich flora and fauna in the wild, the country is also rich in agricultural biodiversity. Mesoamerica is a center of origin and diversity for many globally-important crops such as maize, bean, papaya, pumpkins, avocado, cocoa, cassava, sweet potatoes, and peppers (Khoury et al 2016). There are also numerous lesser-known crops native to Guatemala that are important to indigenous food cultures as documented by Azurdia (2016; Box 1). The high agricultural biodiversity in Guatemala partly results from and reflects the high cultural diversity that exists in this country, where the majority of the population is indigenous or of mixed indigenous and European ancestry and a large number of ethnic groups coexist (Minority Rights Group International 2015). Most Guatemalans are of indigenous descent, including K'iche 9.1%, Kaqchikel 8.4%, Mam 7.9%, Q'eqchi 6.3%, and other Mayan groups 8.6% (2001 census; Minority Rights Group International 2015). A rich knowledge on the use of local biodiversity is maintained by indigenous peoples for leveraging their values for meeting subsistence needs of food, shelter, and medicine. The native plants used by these peoples are

often wild-collected or semi-domesticated and have not received much research attention to enhance their roles in the livelihoods of Guatemalan peoples—even if some have much higher nutrition values and higher stress tolerance than more commercial crops introduced by European colonizers (Azurdia 2016). Two examples of underutilized crops that can support better nutrition and climate resilience in Guatemala are chaya and tepary bean, which are discussed in detail below.

Box 1. Underutilized vegetables and fruits in Mesoamerica. Source: Azurdia 2016

Vegetables

Anillito (*Rytidostylis gracilis*), calá (*Carludovica palmata*), castanichaj (*Solanum wendlandii*), colinabo (*Brassica campestris*), chomté (*Lycianthes synanthera*), hierba de San Nicolás (*Calandrinia micrantha*), hierba madre (*Jaltomata procumbens*), lechuguilla de conejo (*Sonchus oleraceus*), mácare (*Galinsoga parviflora*), malvilla (*Anoda cristata*), mozote (*Bidens pilosa*), pichojol (*Tinantia erecta*), siete camisas (*Liabum sublobatum*), tunay (*Dahlia imperialis*), verdolaga (*Portulaca oleracea*)

Fruits

Arbol de campeche (*Prosopis juliflora*), canistel (*Pouteria campechiana*), cericote (*Cordia dodecandra*), chucte (*Persea schiedeana*), chupe (*Saurauria kegeliana*), injerto (*Pouteria viridis*), Juruguay (*Talisia oliviformis*), manzanita (*Vaccinium confertum*), matasano (*Casimiroa edulis*), pataxte (*Theobroma bicolor*), pepino dulce (*Solanum muricatum*), ramón (*Brosimun alicastrum*), sauco (*Sambucus mexicana*), tomate de árbol (*Solanum betaceum*)

Chaya

Mayan spinach or chaya (*Cnidoscolus aconitifolius*) is a domesticated shrub that has been cultivated since pre-Hispanic times in the Mayan region (Ross-Ibarra & Molina-Cruz 2002). It was likely domesticated in the Yucatan region of Mexico but it is used commonly throughout Mesoamerica, including Guatemala, Belize, southeast Mexico, and parts of Honduras (Ross-Ibarra 2003). Four cultivated varieties exist: estrella, mansa, plegada, and picuda—all of which are grown in Guatemala (Ross-Ibarra & Molina-Cruz 2002). Chaya is used as a hedge and its leaves are consumed for food and medicine (Ross- Ibarra 2003). It is often planted in gardens, in cornfields, or with other field crops (Ross-Ibarra 2003). The leaves are highly nutritious, containing significantly higher amounts of crude protein, fibre, calcium, potassium, iron, ascorbic acid and β-carotene than spinach (Kuti & Kuti 1999). Cooking slightly reduces the nutritional content but is essential to inactivate toxic hydrocyanic glycosides (Kuti & Kuti 1999). Although the nutritive and agronomic potential of this shrub has been recognized for decades, along with its good taste, there has been little research and promotion of its use (Ross-Ibarra & Molina-Cruz 2002). The species has strong potential to enhance nutrition in communities in the dry corridor but also more widely in Guatemala and in distant markets. Promotion of chaya as a

superfood could be an important income generation opportunity and its greater use can valorize this local food that was an important feature in the pre-Columbus diet.

Tepary bean

Common bean (*Phaseolus vulgaris*) is a staple in Guatemalan cuisine that originated in humid parts of Mesoamerica. Tepary bean (*Phaseolus acutifolius*) is a relative of common bean, thought to have been domesticated in dry regions of Central Mexico and the southwestern USA (Blair et al. 2012). Tepary bean is well-adapted to arid conditions, exhibiting a high level of drought, heat and cold tolerance, as well as early maturation (Blair et al. 2012, Beebe et al. 2013). Tepary bean is fairly high yielding and notably outperforms common bean in hot environments (Beebe et al 2013). This crop is underutilized, grown at a limited scale in dry parts of Mesoamerica but it shows potential to support climate change adaptation of farming systems in this region through greater use and crossing with common bean (Blair et al. 2012, Gaur et al. 2015). The beans are comparable or superior in nutritional content compared to major pulses, with protein content between 17-32% (Nabhan & Felger 1978, Scheerens et al. 1983). Two general types exist: white-seeded and brown-seeded, with the latter characterized by a stronger and more distinctive flavour (Scheerens et al. 1983). The culinary properties of tepary bean are distinct from common bean and Mexicans use different recipes to prepare these two pulses (Scheerens et al. 1983). In the southwestern USA, some prefer tepary bean to common bean and use it as a prized soup ingredient (Scheerens et al. 1983). Evaluations of organoleptic quality by students in Saudi Arabia revealed tepary bean to be moderately to highly acceptable (Tinsley et al. 1985). Nevertheless, their “unfamiliar” taste was believed to have contributed to a failure of early commercialization attempts for tepary beans in USA, while others contend the failure of these attempts was due to poor timing of the interventions (Nabhan & Felger 1978, Scheerens et al. 1983). The acceptability of this crop as an alternative to common bean in Guatemala is being investigated in the project.

Holistic value chain approach

The programme “Linking agrobiodiversity value chains, climate adaptation and nutrition: Empowering the poor to manage risk” aims to strengthen the capacities of farmers to manage risks associated with climate change, poor nutrition status, and economic disempowerment through agrobiodiversity-based solutions. Enhancing productivity and promoting cultivation and use of nutritious and climate-hardy underutilized species is the core of the initiative, which is focusing on chaya and tepary bean in Guatemala. A holistic approach addressing multiple bottlenecks in supply and demand is being applied for chaya, engaging consultation and participation of multiple stakeholders to ensure the interventions are pro-poor and gender-sensitive and to advocate for supportive policies (Padulosi et al. 2014, 2015). Tepary is being introduced to farmers through participatory crop evaluation trials, which also involve a taste component (Bioversity International 2015), and to consumers through acceptability trials.

Baseline study

Target sites

The project is targeting communities in Chiquimula district with activities to promote the cultivation and use of chaya and tepary bean (Figure 2). This district is part of the dry corridor and the population faces a high burden of malnutrition, poverty and climate risk as discussed above. A collaborative alliance was established between Mancomunidad Copan´chortí and UVG to identify food security vulnerable communities to participate in the project. The Mancomunidad Copan´chortí is composed of municipalities and the Majors of four Districts (Jocotán, Camotán, San Juan Ermita and Olopa) and promotes rural development. Women and men leaders, as well as the Presidents of the Comunal Development Committees (COCODES) from five Communities (La Brea, Petentá, Tesoro Abajo, Dos Quebradas and La Arada), were invited to attend a workshop where the Project objectives and activities were presented. Among the participants, three communities were chosen as the primary focus: Tesoro Abajo, Petentá and La Brea (Table 1). Tesoro Abajo is in the municipality of Jocotán with a population of 40,903. The other two villages are in the municipality of Camotán which has a census population of 36,226. The total population of the three villages surveyed was 99 families.

Table 1. Villages targeted for the baseline study in the three focal blocks of Madhya Pradesh

Village	Abbrev	Municipality	Baseline household survey N	Diet diversity survey N
Tesoro Abajo	Tes	Jocotán	29	28
Petentá	Pet	Camotán	31	28
La Brea	LaB		28	24
		Total	88	80

Baseline household survey

The baseline household survey was carried out for 68 families in the target villages in December 2015. To expand the scope of the survey, another 20 households were interviewed by Mancomunidad Copan´Chortí in March 2016. The total sample size was thereby 88 households. Questions in the baseline household survey pertained to household assets, their production system (crops and livestock), income sources, management, sale and consumption of chaya, food and nutrition security, and foods consumed in lean periods and abundant periods of the year. The questionnaire developed for the project was adapted for implementation with Open Data Kit (ODK) on a smartphone.

Diet diversity survey

To complement the baseline household survey, an additional survey on household dietary diversity was carried out in March 2016 taking into consideration 80 households: 28 were interviewed in Tesoro Abajo, 28 in Petentá, and 24 in La Brea. The diet diversity survey followed the Household Dietary Diversity Score method (Swindale and Bilinsky 2005), in which the female head of household was asked to recall the foods eaten by her household in the last 24 hours.

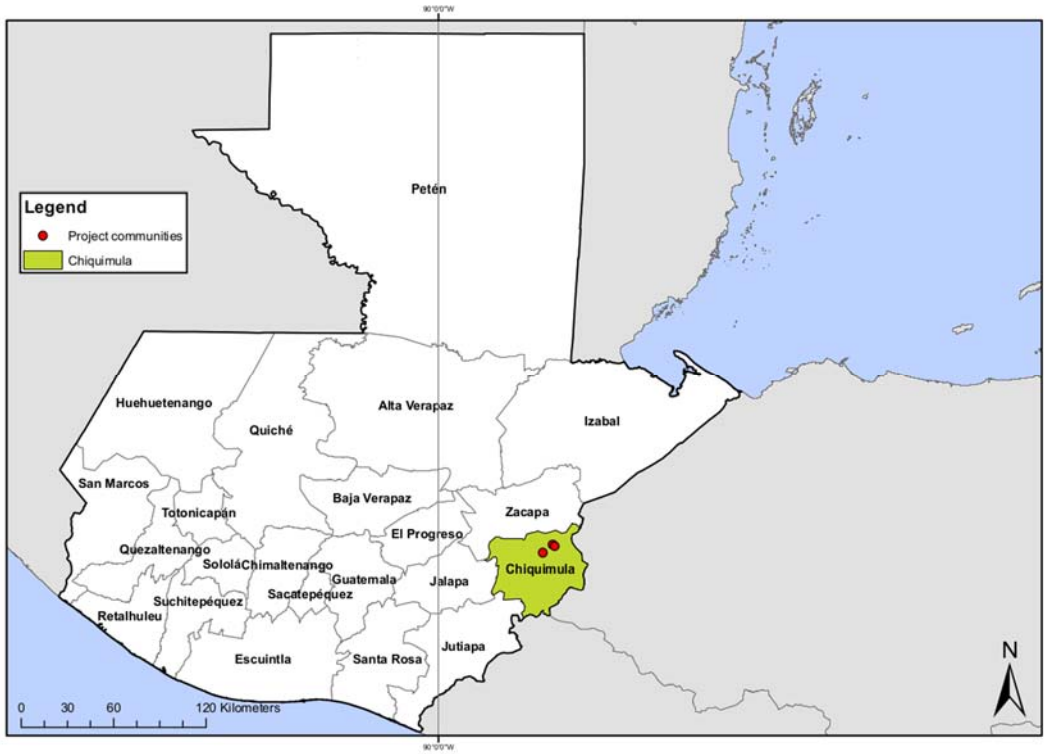

Figure 1. Target sites of the project in Guatemala

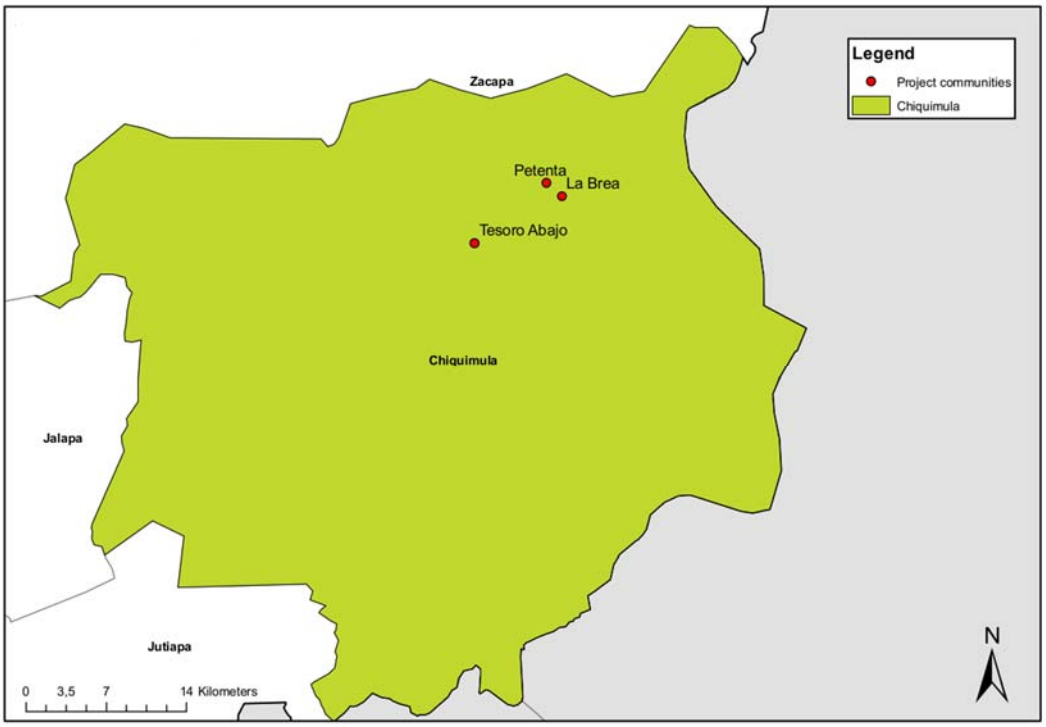

Figure 2. Targeted villages in Chiquimula district of Guatemala

Data analysis and interpretation

This document summarizes the main results of the baseline surveys with the aim to guide further investigation and actions in the Project. The analysis focuses on visualizing and identifying key patterns in the data. Comparisons are made between communities for orientation but statistical tests were not performed, so the differences discussed here are not necessarily significant. The analysis was performed in R (Version 3.02 R Foundation for Statistical Computing) and Excel (Microsoft 2013).

The survey design anticipated to have the position of each respondent documented by GPS however, due to issues with satellite connectivity, the GPS position was not documented for every respondent and some uncertainty thereby resulted for the location of some surveys. Comparing the time stamp of the survey relative the field schedule and cross checking with the names of farmers surveyed in the household diet diversity survey was performed to identify the site for those surveys where the information on location was missing. A certain level of error resulted from this process, thus the most reliable results in this assessment are those for the overall sample, which aggregate the three communities. Additional sources of error are in the identification of crop species and varieties, which was made based on common name. Further work is required for some crops to assess the species name where several species could be associated to one common name and for some common names that could not be linked to scientific names by the investigators. More work is also needed to control for synonyms in variety names between households and communities, which is work that is ongoing in the Project.

Respondent and household characteristics

Gender, age, and education

Almost all the interviewees for the baseline household survey were women (95%) and in most cases they were the female head of household (83%; Table 2). In four cases, a man was interviewed. In three of these cases, the man interviewed was not the head of household, while in the fourth case, details on the head of household were not provided. The age and education of the respondents is shown in Table 3. The respondents ranged from 14 to 74 years of age, with a mean age of 37. The level of education with generally low. Just 22.7% had completed primary school and 3.4% had also completed secondary school. Thirty-two percent could read and write but had not completed primary school, while 45% were illiterate and had not received formal education.

Table 2. Gender and position in household of respondents in the baseline household survey

	All	LaB	Pet	Tes
Female respondent	84	28	29	27
Head of household	73	25	25	23
Other	9	3	2	4
Male respondent	4	0	2	2
Head of household	0	0	0	0
Other	3	0	2	1

Table 3. Age and years of formal education of the respondents

	All	LaB	Pet	Tes
Mean age	37	35	36	41
Min age	14	19	20	14
Max age	74	68	74	68
Illiterate	40	13	12	15
Can read and write	28	10	10	8
Can read and write and has completed primary school	17	7	7	6
Completed secondary school	3	2	2	0

Ethnicity

Respondents were asked to name their ethnicity. 39% considered they were ladino, 31% maya, and the remaining 31% did not reply to this question (Table 4). In Chiquimula, the specific Maya group is ch'orti'.

Table 4. Age and years of formal education of the respondents

	All	LaB	Pet	Tes
Ladino	34	11	11	12
Maya	27	7	6	14

Household size and composition

Seventy-five percent of the households were headed by a man and a woman who were both living in the home (Table 5). Fewer households (14.7%) were headed by a single woman who was widowed or whose husband was absent from the home. One household did not have a head, either because they were absent or because the house was inhabited by an orphan. Several households (9%) did not answer the question regarding their household composition. The mean age of the male head of household was 44 years and of the female head of household was 41 years.

The size of the households ranged from 1 to 13, with a mean of 5.9 inhabitants (Table 6). The mean ratio of adult women to men was biased toward women. The mean number of children (under 14 years of age) per household was 2.4. Households were similar in size and composition in each village.

Table 5. Details on the heads of the surveyed households

	All	LaB	Pet	Tes
Man and woman (consolidated couple, both living in the home)	66	20	24	22
Single woman (widow or man absent from home)	13	1	5	7
Absent or orphaned heads of household	1	1		
Male head of household				
Mean age	44	40	44	50
Max age	79	79	71	76
Min age	23	23	25	27
Female head of household				
Mean age	41	37	40	45
Max age	74	68	74	68
Min age	19	19	20	23

Table 6. Size and composition of surveyed households

	All	LaB	Pet	Tes
Min household size	1	1	2	3
Mean household size	5.9	6.3	5	6.4
Max household size	13	13	10	11
Mean # of children (<14)	2.4	2.6	2.3	2.3
Mean # of youth (14 to 19)	0.9	0.9	0.7	1.1
Mean # of adults (>20)	2.5	2.7	1.9	2.9
Mean prop. of adults in the household that are female	0.7	0.7	0.8	0.6

Wealth

The progress out of poverty index (PPI) was used as an indicator of wealth for the surveyed households (Grameen Foundation 2016). The index is based on 10 country-specific questions, which assess household characteristics and assets. For Guatemala, the questions relate to how many household members are 13 years of age or younger, whether all children between the ages of 7 to 13 were enrolled in school, if the female head of household could read and write, if any household members worked mainly as casual laborers or domestic workers, the construction material of the residence's floors, whether they had a refrigerator, gas or electric stove, stone mill, or electric iron, as well as if they had ungulate livestock (cow,

bulls, calves, pigs, horses, donkeys, or mules) (Schreiner and Woller 2010). The answers to each question were matched to defined categories with associated scores. The sum of the scores for each question was calculated to give the PPI score, which ranges between 0 and 100 and is linked to a standardized set of poverty likelihoods. Lower PPI scores indicate higher probability of poverty.

The mean progress out of poverty index score for the households surveyed was 20.8 (Table 7). The mean likelihood that households fell below the national poverty line was 80% (Schreiner and Woller 2010). The poverty likelihood ranged from a minimum 7.3% to maximum 80.2%. The mean poverty likelihood was similar across the villages.

Table 7. Progress out of poverty index (PPI) score and poverty likelihood of surveyed households

	All	**LaB**	**Pet**	**Tes**
Mean PPI score	20.8	20.5	21.3	20.9
Poverty likelihood (probability of falling below national poverty line)				
Mean (%)	80.2	80.4	77.3	83.1
Min (%)	7.3	25.5	7.3	52.2
Max (%)	100.0	100.0	100.0	100.0

Farm characteristics

Land

The landholdings of the surveyed households are summarized in Table 8. The mean landholding size for all the households surveyed was 0.7 Ha. The smallest landholdings were 0.06 Ha and the largest landholdings were 3.9 Ha. Landholdings were similar across the three villages. Most respondents documented their landholdings in tarea, for which the conversion to metric measurements can vary slightly. For this analysis a conversion of 15.9 tarea per hectare was applied. A few respondents indicated their landholdings in cuerda, which include 6 tarea.

74% of the households owned at least some of their land and 48% were renting some land. One in five households (20%) did not own any land and were dependent on rented plots (Table 9). Land was allocated to different uses as described in Table 10. Most households (97%) had land under rainfed cultivation, and most of the area was under this land use (mean 0.6 Ha). Fewer households (4.5%) had land under irrigated cultivation and the area was quite small when they did have irrigated holdings (mean 0.2 Ha).

Table 8. Households' total landholdings owned and rented (means with zeros excluded)

	All	LaB	Pet	Tes
Mean landholdings (Ha)	0.73	0.56	0.69	0.94
Min. landholdings (Ha)	0.06	0.06	0.25	0.06
Max. landholdings (Ha)	3.93	1.35	1.89	3.93

Table 9. Land ownership of the surveyed households (means with zeros excluded)

	All	LaB	Pet	Tes
# owning land	65	22	26	17
Mean area owned (Ha)	0.5	0.5	0.6	0.5
# renting land	42	13	13	16
Mean area rented (Ha)	1.1	0.4	0.5	2.2
# only renting land	18	6	4	8
# renting land to others	9	5	2	2
Mean area rented (Ha)	0.3	0.04	0.03	0.02

Table 10. Land ownership of the surveyed households (means with zeros excluded)

	All	LaB	Pet	Tes
# with rainfed cultivation	85	27	31	27
Rainfed area (Ha)	0.57	0.47	0.53	0.72
# with irrigated cultivation	4	1	2	1
Irrigated area (Ha)	0.17	0.31	0.09	0.19

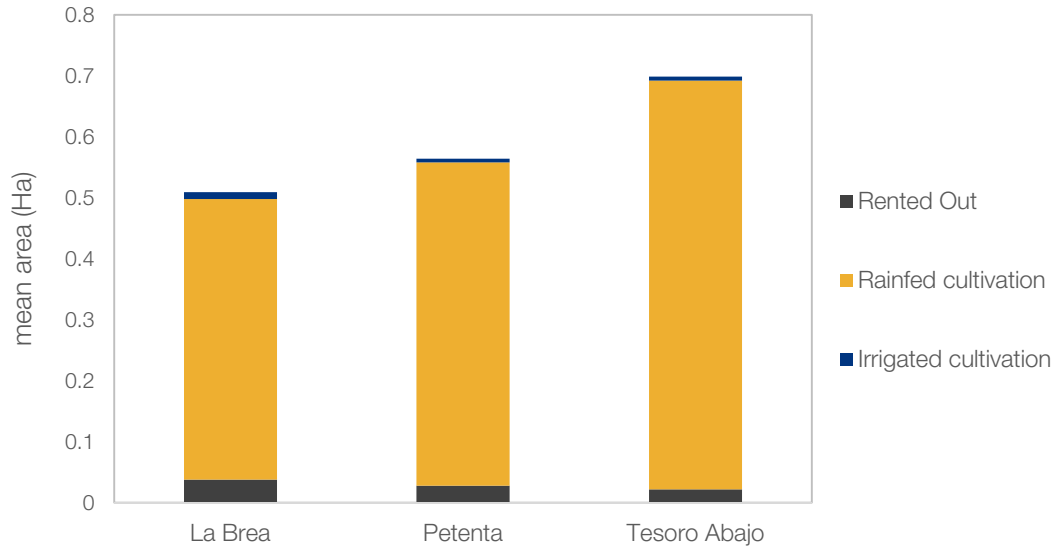

Figure 3. Mean area for different land use types in the three focal blocks (incl. zeros)

Livestock

Sixty-one percent of the surveyed households were keeping livestock. The most common types of livestock overall were chickens (*Gallus gallus domesticus*; 60%) and ducks (*Anas platyrhynchos*; 19%) (Table 11). Less common livestock were pigs (*Sus scrofa domesticus*; 4.5%), turkeys (*Meleagris gallopavov*; 2.3%) and donkeys (*Equus africanus asinus*; 1.1%). There was not a big difference in the livestock kept between communities (Figure 5). In total, five livestock species were kept across the sites. Households maintained a mean of 1.5 livestock species.

Households that kept chickens had a mean of 18 animals (Table 12). For ducks, a mean of 5 animals were kept and for turkeys a mean 2.5 animals were maintained. Households on average had just one pig or donkey. In Tesoro Abajo, households maintained slightly higher head counts of chickens than in the other villages (Figure 4).

Table 11. Number of households keeping livestock species and livestock richness

	All	LaB	Pet	Tes
# households keeping livestock	54	16	18	20
Chicken	53	17	16	20
Duck	17	6	5	6
Pig	4	1	2	1
Turkey	2	2		
Donkey	1			1
Total # species	5	4	3	4
Household species richness	1.5	1.4	1.3	1.7

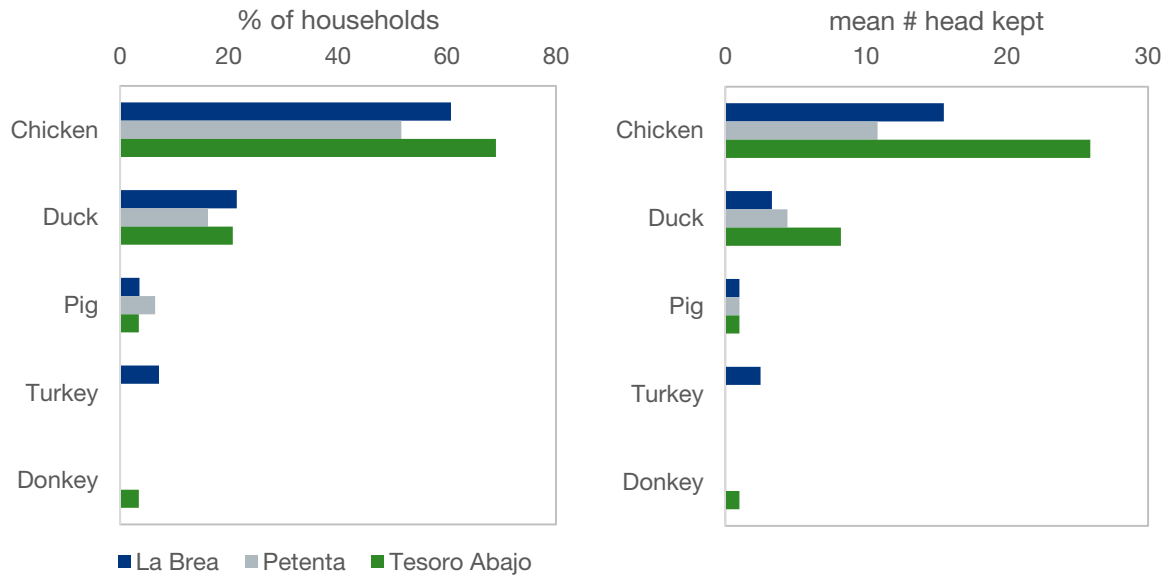

Figure 4. Percent of households maintaining species of livestock and the mean number of head maintained (incl. zeros)

Table 12. Mean number of heads of livestock maintained

	All	LaB	Pet	Tes
Chicken	18	15.5	10.8	25.9
Duck	5.4	3.3	4.4	8.2
Turkey	2.5	2.5		
Pig	1	1	1	1
Donkey	1			1

Crops

A total of 25 crop species were documented in the surveyed communities, including two cereals, one legume, 14 vegetables, five fruits, and two other crops (Table 13, 14). One household in Petenta was noted to be growing a fruit tree but the species was not noted. There were also four records of households growing crops aside from the major cultivations, for which the crop name was not specified. Overall, households maintained a mean of 2.8 crop species, including 0.6 cereal crops, 0.7 legume species, 0.7 vegetables, 0.2 fruits, and 0.2 'other' crops (Table 15).

Table 13. Total number of species of different crop types documented in different areas

	All	LaB	Pet	Tes
Overall	26	9	12	23
Cereals	2	1	2	2
Legumes	1	1	1	1
Vegetables	15	5	6	12
Fruits	6	1	1	6
Other	2	1	2	2

Table 14. Number of households growing crop species and crop species richness

Species name	Common names	Origin
Cereals		
Zea mays	Maize, maíz	C America and Mexico[a, b]
Sorghum sp.	Sorghum, maicillo	W,C, E & S Africa[a]
Legumes		
Phaseolus vulgaris	Common bean, frijol	C America and Mexico[a, b]
Vegetables		
Allium cepa	Onion, cebolla	W & C Asia[a]
Brassica oleracea var. *capitata*	Cabbage, repollo, cole	S&E Mediterranean, SW, SE, N Europe, W,E&C Asia[a]
Capsicum sp.	Chile	C America and Mexico, Tropical South America, Caribbean[a, b]
Cnidoscolus aconitifolius	Chaya, mayan spinach	Mesoamerica[c]
Coriandrum sativum	Cilantro, corriander	Europe, Asia
Crotalaria longirostrata	Chipilín	Mesoamerica[c]
Cucurbita argyrosperma	Ayote, cushaw pumpkin	Mesoamerica[b]
Fernaldia pandurata	Loroco	Mesoamerica[e]
Manihot esculenta	Yuca	C America and Mexico, Tropical South America
Mentha spicata	Hierbabuena, spearmint	Europe, Asia
Sechium edule	Chayote, guisquil	Mesoamerica[b]
Solanum americanum and S. nigrescens	Hierba mora, American black nightshade and divine nightshade	Mesoamerica[c]
Solanum lycopersicum	Tomato, tomate	Andes
Raphanus sativus	Radish, rabano	Europe, Asia[d]
Verbenaceae	Dante	
Fruits		
Eriobotrya japonica	Loquat, nispero	SE China and possibly southern Japan[f]
Mammea americana	Mamey	West Indies and northern South America[f]
Musa sp.	Banana, banano, plantain, plátano	S & SE Asia[a]
Mangifera sp.	Mango	S & SE Asia[a]
Pouteria sapota	Zapote	Mesoamerica[f]
Other		
Coffea sp	Coffee, café	E, W, C Africa[a]
Theobroma cacao	Cacao	C America and Mexico, Tropica S America[a]

[a] Khoury et al 2016
[b] Delgado-Salinas et al 2003
[c] Azurdia 2016
[d] Crop genebank knowledge base 2016
[e] Morton et al 1990
[f] Morton et al 1987

Table 15. Mean number of species of different crop types kept at the household level (incl. zeros)

	All	LaB	Pet	Tes
Overall	2.8	2.7	2.2	3.7
Cereals	0.58	0.54	0.55	0.66
Legumes	0.69	0.79	0.61	0.68
Vegetables	0.68	0.61	0.55	0.90
Fruits	0.20	0.11	0.13	0.38
Other	0.15	0.14	0.06	0.24

Table 16. Number of households growing crop species and crop species richness

	All	LaB	Pet	Tes
Cereals	**50**	**15**	**16**	**19**
Zea mays	47	15	14	18
Sorghum sp.	4		3	1
Legumes	**43**	**15**	**11**	**17**
Phaseolus vulgaris	43	15	11	17
Vegetables	**30**	**9**	**8**	**13**
Cnidoscolus aconitifolius	27	8	7	12
Crotalaria longirostrata	8	4	3	1
Solanum americanum and S. nigrescens	5	3	2	
Coriandrum sativum	3		2	1
Raphanus sativus	3		2	1
Solanum lycopersicum	3	1		2
Brassica oleracea	2			2
Allium cepa	2			2
Cucurbita argyrosperma	1		1	
Capsicum sp.	1			1
Sechium edule	1			1
Mentha spicata	1			1
Fernaldia pandurata	1			1
Verbenaceae	1			1
Manihot esculenta	1	1		
Fruits	**12**	**3**	**3**	**6**
Musa sp.	11	3	3	5
Mammea americana	1			1
Mangifera sp.	1			1
Eriobotrya japonica	1			1
Pouteria sapota	1			1
Musa sp. Plantain subgroup	1			1
Unspecified fruit tree	1		1	
Other	**11**	**4**	**1**	**6**
Coffea sp	11	4	1	6
Theobroma cacao	2		1	1

The most popularly cultivated crops overall were maize (*Zea mays*; 53%) and common bean (*Phaseolus vulgaris*; 49%) (Table 16). Aside from maize, the only other cereal documented in the sites was sorghum (*Sorghum* sp.; 5%), which was quite rare. No other legume was documented aside from common bean. Chaya (*Cnidoscolus aconitifolius*; 31%) was the most popularly cultivated vegetable. Other vegetables documented were chipilin (*Crotalaria longirostrata*; 9%), hierba mora (*Solanum americanum* and *S. nigrescens*; 6%), cilantro (*Coriandrum sativum*; 3%), radish (*Raphanus sativus*; 3%), tomato (*Solanum lycopersicum*; 3%), repollo (*Brassica oleracea* var. *capitata*; 2%), onion (*Allium cepa*; 2%), ayote (*Cucurbita argyrosperma*; 1%), chile (*Capsicum* sp.; 1%), guisquil (*Sechium edule*; 1%), hierbabuena (*Mentha spicata*; 1%), loroco (*Fernaldia pandurata*; 1%), yuca (*Manihot esculenta*; 1%), and dante (probable Verbenaceae; 1%). It was unclear whether chaya was indeed more popular than the other vegetables as the survey explicitly asked about chaya cultivation and this likely led to this crop being documented with greater likelihood than other vegetables. Banana (*Musa* sp. 13%) was the most common fruit, noting that one household was also growing plantain (*Musa* sp. Plantain subgroup; 1%). Less common fruits were mamey (*Mammea americana*; 1%), mango (*Mangifera* sp.; 1%), nispero (*Eriobotrya japonica*; 1%), and zapote

(*Pouteria sapota*; 1%). In addition to the food crops, coffee (*Coffea* sp; 13%) was commonly grown and cocoa (*Theobroma cacao*; 2.3%) was grown by one household. A higher diversity of fruits and vegetables were documented in Tesoro Abajo but otherwise the crops were similar between sites (Figure 6).

Table 17. Mean area (hectares) allocated to crop by growers (excl. zeros)

	All	LaB	Pet	Tes
Cereals	**0.94**	**0.85**	**0.82**	**1.11**
Zea mays	1.00	0.86	0.90	1.00
Sorghum spp	0.20		0.20	0.30
Legumes	**0.90**	**0.66**	**0.70**	**1.00**
Phaseolus vulgaris	0.90	0.66	0.70	1.00
Vegetables	**0.50**	**0.85**	**0.40**	**0.30**
Verbenaceae	2.00			2.00
Crotalaria longirostrata	0.60	0.89	0.40	<0.01
Solanum americanum and S. nigrescens	0.40	0.65	0.10	
Manihot esculenta	0.30	0.31		
Cnidoscolus aconitifolius	0.20	0.23	0.20	0.20
Raphanus sativus	0.10		0.08	0.20
Coriandrum sativum	0.08		0.08	0.09
Cucurbita argyrosperma	0.06		0.06	
Brassica oleracea var. capitata	0.05			0.05
Allium cepa	0.03			0.03
Solanum lycopersicum	0.03	<0.01		0.04
Fernaldia pandurata	0.01			0.01
Capsicum sp	<0.01			<0.01
Sechium edule	<0.01			<0.01
Mentha spicata	<0.01			<0.01
Fruits	**0.04**	**0.04**	**0.02**	**0.04**
Eriobotrya japonica	0.05			0.05
Musa sp.	0.04	0.04	0.02	0.04
Mammea americana	<0.01			<0.01
Mangifera sp.	<0.01			<0.01
Pouteria sapota	<0.01			<0.01
Musa sp. Plantain subgroup	<0.01			<0.01
Unspecified fruit tree	<0.01		<0.01	
Other	**0.31**	**0.47**	**0.13**	**0.23**
Coffea sp	0.30	0.47	0.10	0.20
Theobroma cacao	0.02		0.01	0.02

Household's assigned largest areas to maize (mean 1.0 Ha) and beans (mean 0.9 Ha) (Table 17). The few households cultivating sorghum grew it in smaller area (mean 0.2 Ha). When grown, vegetables were assigned a mean area of 0.5 Ha. Most vegetable species occupied small areas (<0.1 Ha). Chipilin, hierba mora, dante, and chaya were grown in relatively larger areas than other vegetables (0.2 to 2.0 Ha). Relatively larger areas were assigned to vegetable cultivation in La Brea (Figure 6). For some plants, especially chaya, the area was documented in number of trees or number of bushels. A conversion rate of 2 m^2 area for one tree was assumed for this analysis.

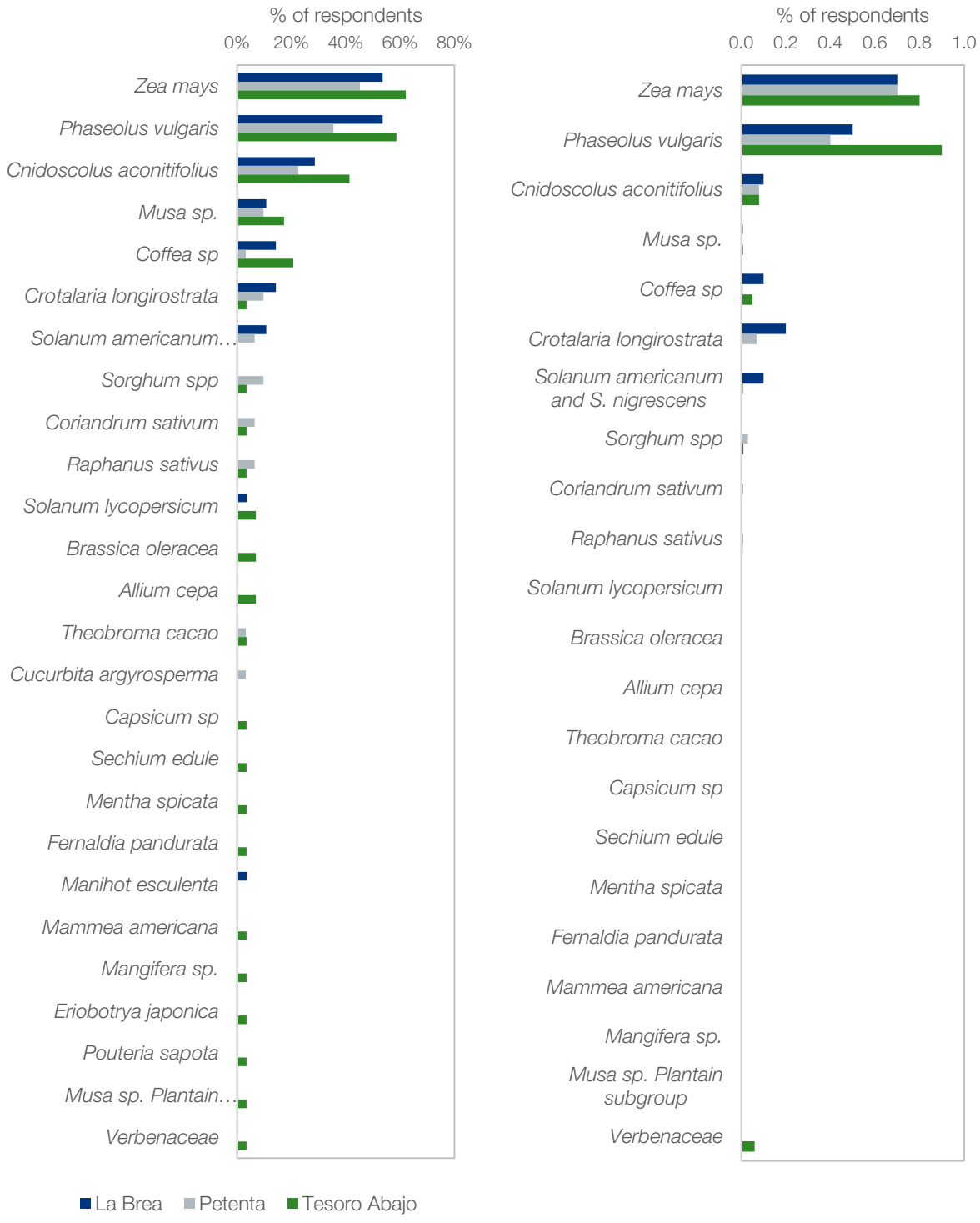

Figure 5. Percent of households cultivating different crops and the mean area cultivated (incl. zeros)

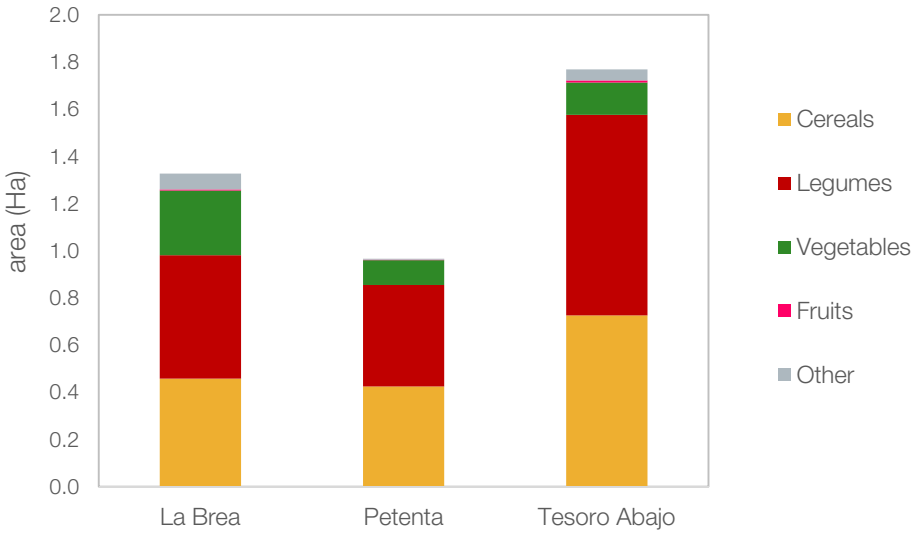

Figure 6. Mean area grown of different crop types (incl. zeros)

Household Income

The baseline household survey assessed the diversity of sources from which households drew their income. The livelihood sources included crops, livestock, livestock products, and off-farm sources. These different sources of income are described below.

Crops for income

Overall 16% of households reported earning some income from their crop production. The most common crops that were sold for income were common bean and coffee (Table 18). Coffee was sold by 55% of those cultivating the crop and bean was sold by 16% of those producing the crop. Two households were earning some income from fruits and one household was earning income from vegetables. The production of maize was exclusively for subsistence, as was the case for most crops (Figure 9). The above cases aside, production was by and large for household consumption (Figure 10). The majority (84%) of growers did not report making income from their production and 18 of the 26 crops were not sold by any of their producers (Figure 11).

Table 18. Number of households earning income from different crop species

	All	LaB	Pet	Tes
Cereals	**0**	**0**	**0**	**0**
Legumes	**7**	**3**	**0**	**4**
Phaseolus vulgaris	7	3		4
Vegetables	**1**	**0**	**0**	**1**
Allium cepa	1			1
Mentha spicata	1			1
Fruits	**2**	**0**	**1**	**1**
Mangifera sp.	1			1
Pouteria sapota	1			1
Mammea americana	1			1
Unspecified fruit tree	1		1	
Other	**6**	**3**	**1**	**2**
Coffea sp	6	3	1	2
Total earning income from crops	**14**	**5**	**2**	**7**

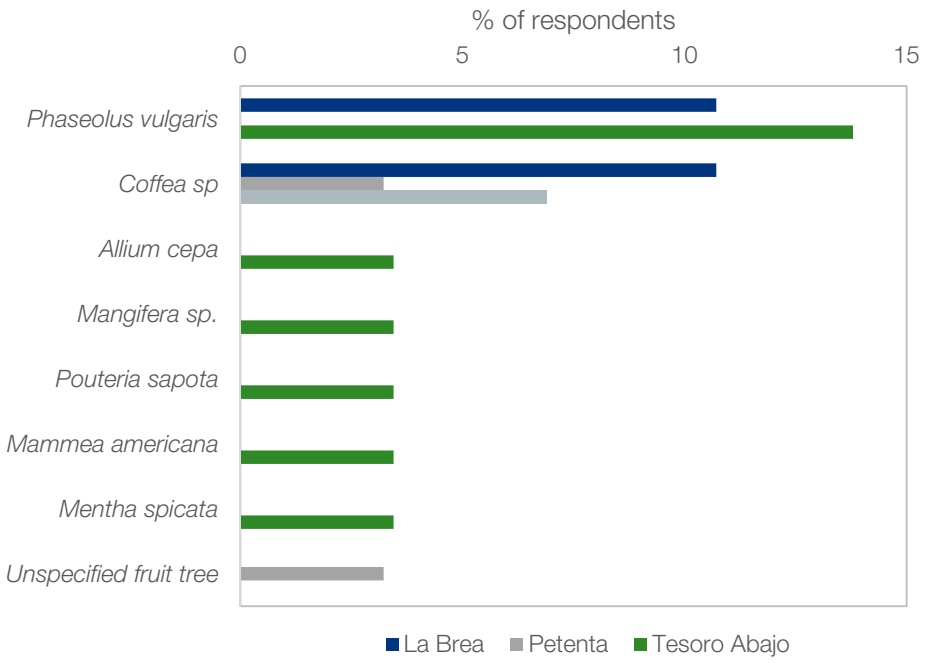

Figure 7. Percent of households reporting crops as a source of income

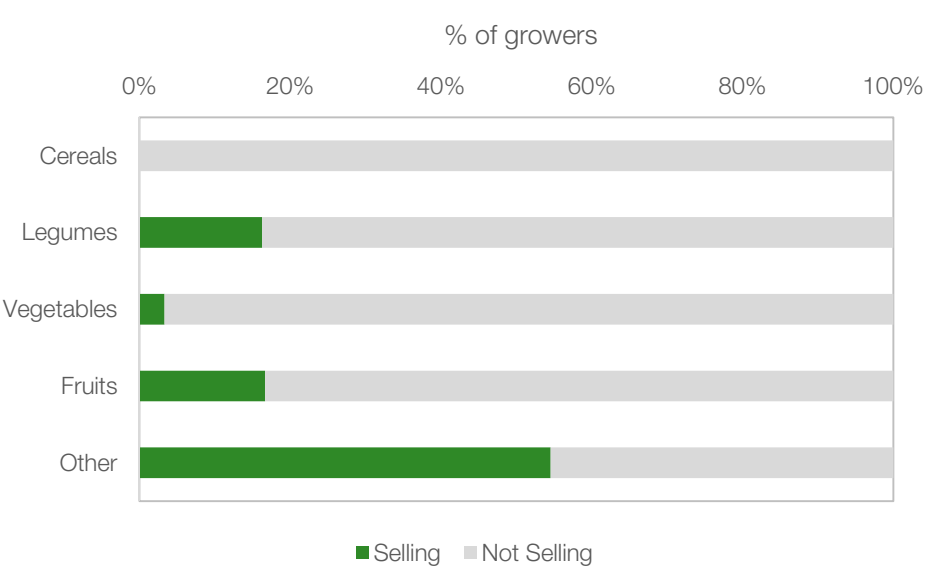

Figure 8. The proportion of growers of different crop types that were earning income

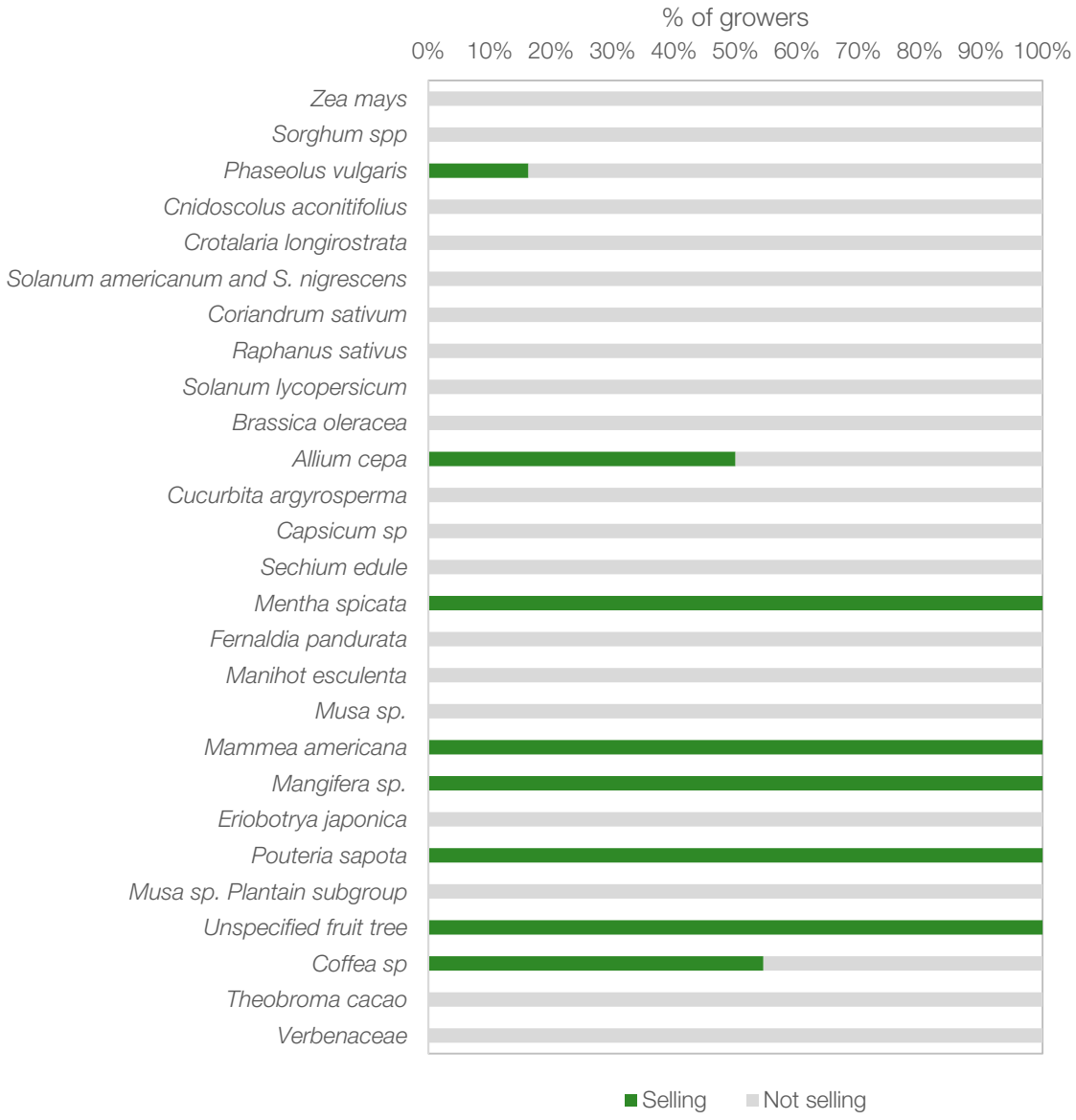

Figure 9. Percent of growers reporting crops as a source of income

Livestock for income

Few households were making an income from livestock or livestock products. Just three households reported selling chickens as a source of income: two in Tesoro Abajo and one in Petenta. This was just 6% of the households that were keeping chickens. Four different households reported selling eggs, including three in Petenta and one in La Brea.

Off-farm income sources

A quarter of households reported having off-farm income sources. The most common off-farm income source was farm labor (Table 19). 9% of households had members who were day laborers on farms outside the community, while 2% had members doing farm labor on neighboring farms. Two households had their own business, one household had a member that was a domestic employee, and one household had another kind of temporary work in the community.

Table 19. Number of households reporting livelihood sources

	All	LaB	Pet	Tes
Day laborer on farms outside the community	8	5	2	1
Day laborer on neighboring farms	2	2		0
It has its own business (eg. shop)	2			2
Domestic Employee	1			1
Temporary work of another type in the community (promoter, facilitator, etc.)	1		1	
Other unspecified off farm income source	12	3	5	4
Number households with off farm income sources	**22**	**8**	**7**	**7**

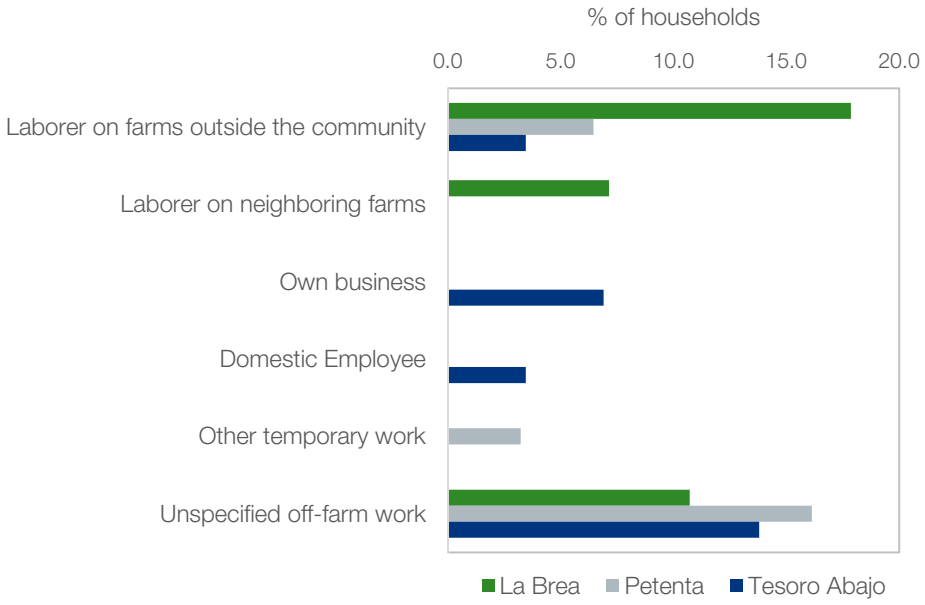

Figure 10. Percent of households reporting livelihood sources as income sources

Types and numbers of income sources

The households surveyed had a total of 14 unique sources of income, considering all the specific crops, livestock, animal products, and off-farm sources (Table 20). Overall, individual households had a mean of 0.6 income sources— less than one (Table 21). Households in Tesoro Abajo had the most sources of income on average and households in Petenta had the fewest sources of income recorded at the household

level among the communities. The average household had 0.23 cash earning crops, 0.03 cash-earning livestock, 0.05 animal products and 0.3 off farm income sources.

Sixteen percent of households were gaining an income from agriculture and 3% were gaining income from livestock (Figure 16). Twenty five percent were gaining income from off-farm sources. Animal products were a less common source of income, for only 5% of households. Petenta had fewer households gaining an income from crops but more gaining income from animal products than the other communities (Figure 16).

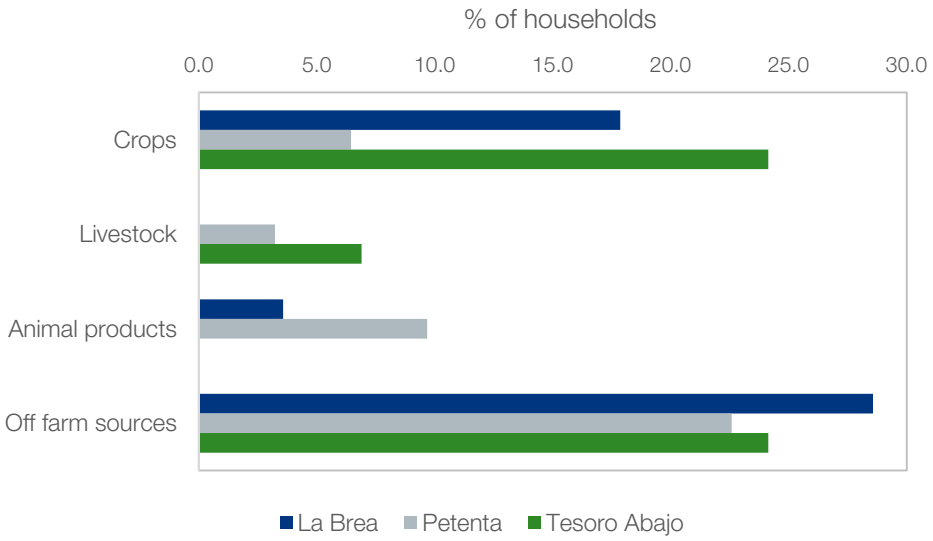

Figure 11. Number of households gaining an income from different types of livelihood sources

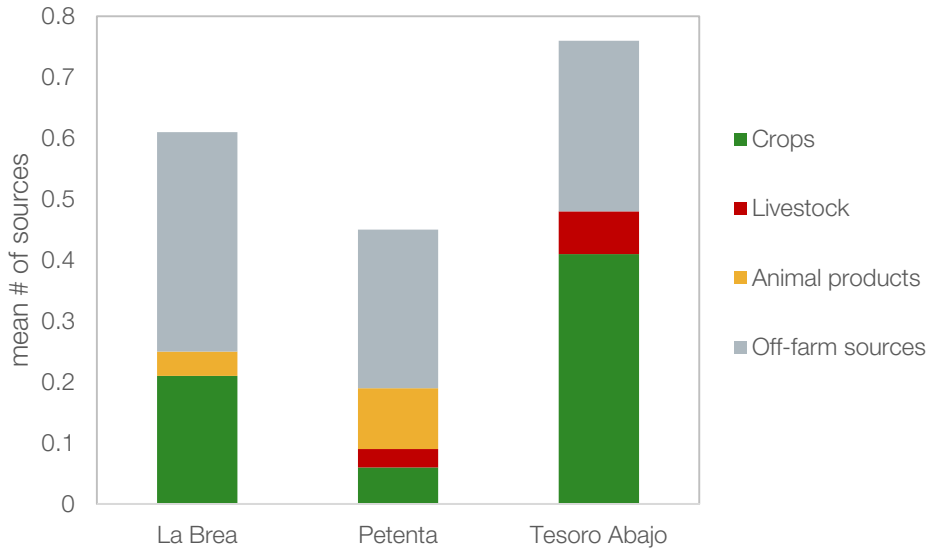

Figure 12. Mean number of livelihood sources of different types at household level (incl. zero)

Table 20. Total number of unique livelihood sources

	All	LaB	Pet	Tes
Total # livelihood sources in region	14	5	5	11
Crops	7	2	1	7
Livestock	1	0	1	1
Animal products	1	1	1	0
Off-farm sources	5	2	2	3

Table 21. Richness of livelihood sources at household level

	All	LaB	Pet	Tes
Mean # livelihood sources at household level	0.60	0.61	0.45	0.76
Crops	0.23	0.21	0.06	0.41
Livestock	0.03	0.00	0.03	0.07
Animal products	0.05	0.04	0.10	0.00
Off-farm sources	0.30	0.36	0.26	0.28

Table 22. Most popular livelihood source ranked by number of households citing income sources

Rank	Overall	La Brea	Petenta	Tesoro Abajo
1	Laborer on farms outside community (9.1%)	Laborer on farms outside community (17.9%)	Eggs (9.68%)	*Phaseolus vulgaris* (13.79%)
2	*Phaseolus vulgaris* (8.0%)	*Phaseolus vulgaris* (10.71%)	Laborer on farms outside community (6.5%)	*Coffea* sp (6.9%)
3	*Coffea* sp (6.8%)	*Coffea* sp (10.71%)	*Coffea* sp (3.23%)	Own business (eg. shop) (6.9%)
4	Eggs (4.6%)	Laborer on neighboring farms (7.14%)	Other temporary work in the community (3.23%)	Chickens (6.9%)
5	Chickens (3.4%)	Eggs (3.57%)	Chickens (3.23%)	*Allium cepa* (3.45%)
6	Laborer on neighboring farms (2.3%)			*Mentha spicata* (3.45%)
7	Own business (eg. shop) (2.3%)			*Mangifera* sp. (3.45%)
8	*Allium cepa* (1.1%)			*Pouteria* sp (3.45%)
9	*Mentha spicata* (1.1%)			*Mammea americana* (3.45%)
10	*Mangifera* sp. (1.1%)			Laborer on farms outside the community (3.45%)
11	*Pouteria* sp (1.1%)			Domestic Employee (3.45%)
12	*Mammea americana* (1.1%)			
13	Domestic Employee (1.1%)			
14	Other temporary work in the community (1.1%)			

Overall, the most common livelihood sources were farm labour (9%) and beans (8%) (Table 22). Coffee was another crop that brought income for several households (7%). Eggs and chickens were the next most common income sources but they were quite rare (3-5% of households). The most common income sources were slightly different in the three villages. Farm labour was a more prominent income source for households in La Brea. Eggs were the most common income source documented in Petenta, while beans were the most important livelihood source documented in Tesoro Abajo (14%).

Cultivation and sale of the target crops

The project is focused on research and development of the value chains of chaya and tepary bean. A detailed assessment was made of the current levels of cultivation and commercialization of these crops, considering the diversity of varieties, as well as the management practices and associated gender roles.

Chaya

Cultivation of chaya

The level of cultivation of chaya in the surveyed blocks is shown in Table 23. Overall 31% of surveyed households were growing chaya. A higher proportion of households was growing chaya in Tesoro Abajo than in La Brea and Petenta. Overall, the farmers allotted a mean 0.1 Ha to chaya, representing about 16% of their landholdings. It is noted that the area estimates are coarse as some households documented the number of bushes and others the area in tarea. With the assumed conversion of one bush representing 2 m^2, the estimated area of chaya cultivation was larger in La Brea compared to the other two communities.

Table 23. Number of households cultivating chaya and area devoted to the crop

	All	LaB	Pet	Tes
# of households growing chaya	27	8	7	12
% of households growing chaya	30.7	28.6	22.6	41.4
Mean area devoted to chaya by growers (Ha)	0.1	0.1	0.1	0.1
Mean % of farmland devoted to chaya by growers	15.8	22.7	10.1	14.5

Table 24. Number of households growing chaya varieties and variety richness

Variety	All	LaB	Pet	Tes
Mansa	18	5	3	10
Estrella	5	3		2
Unspecified*	7	1	4	2
Total # varieties in region	**2**	**2**	**1**	**2**
Mean # varieties at household level	**1.1**	**1.1**	**1.0**	**1.2**

**Not counted in regional variety richness*

Two varieties of chaya were grown across the villages (Table 24). The most common variety was mansa (also known as *criollo* in the surveyed villages) and the second most common variety was estrella (known locally as *extranjero*). Mansa was grown in all three villages, wheras the estrella variety was only documented in La Brea and Tesoro Abajo. In several cases the variety of chaya grown by the household was not specified, so it is possible that the estrella variety was also grown in Petenta. Across the villages households typically only cultivated one variety of chaya and in more rare case, two varieties. A much higher area was assigned to the mansa variety in Tesoro Abajo, whereas the estrella and mansa vareities had similar areas in La Brea (Figure 13, Table 25).

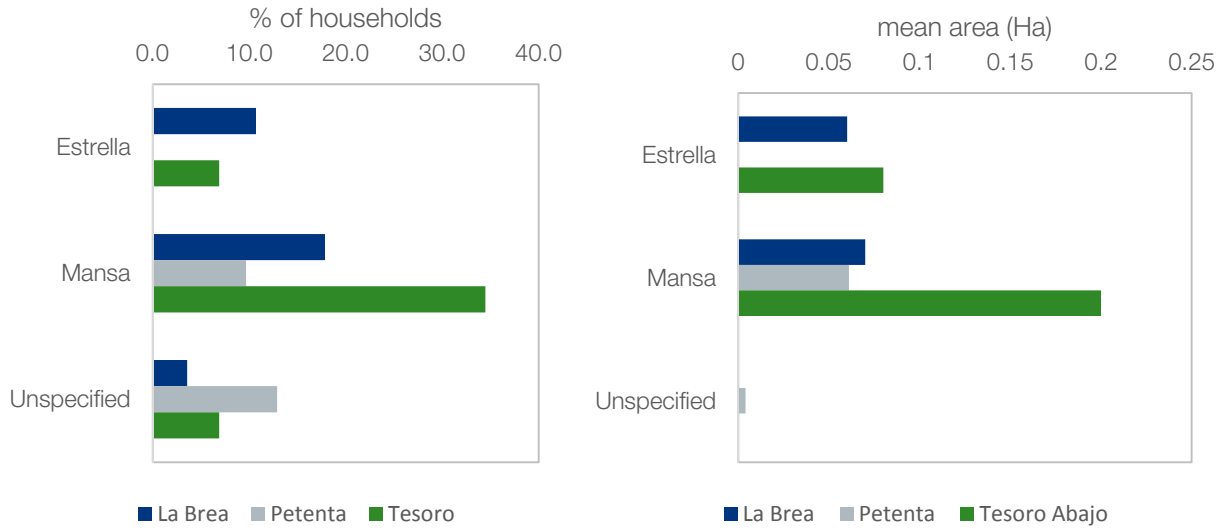

Figure 13. Percent of households growing varieties of chaya and the total area in the sample

Table 25. Mean area of chaya grown at the household level, excl zeros

	All	LaB	Pet	Tes
Estrella	0.75	0.51		1.12
Mansa	0.47	0.38	0.63	0.46
Unspecified	0.02	<0.01	0.03	<0.01

Management of chaya

Chaya was most often managed by women (Figure 14, Table 26). Of chaya growing households, 44% reported that women were the gender most responsibe for its management. 19% reported that men were responsible for managing chaya, while 7% reported that both genders managed chaya. The sources of chaya germplasm were reported in the survey. Effectively all respondents sourced their germplasm from their family members within the community (Table 27). Some got chaya germplasm from a neighbor in the same community. Fewer had received chaya germplasm from a relative outside the community or as a donation from the government or an NGO. The yield of chaya was coarsely estimated, assuming one bunch to equal 1 kg. The estimates revealed average yields of 11 kg/Ha (Table 28). There was indication that the mansa variety was providing higher yields than estrella. It is unclear if farmers were referring to their yields over the whole year or for a specific period of time, as chaya can be harvested year round. In La Brea, few households gave detail on yields of chaya.

Table 26. Number of households reporting gender responsible for management of chaya

	All	LaB	Pet	Tes
Woman	12	4	3	5
Men	5	2	1	2
Both	2	1	0	1

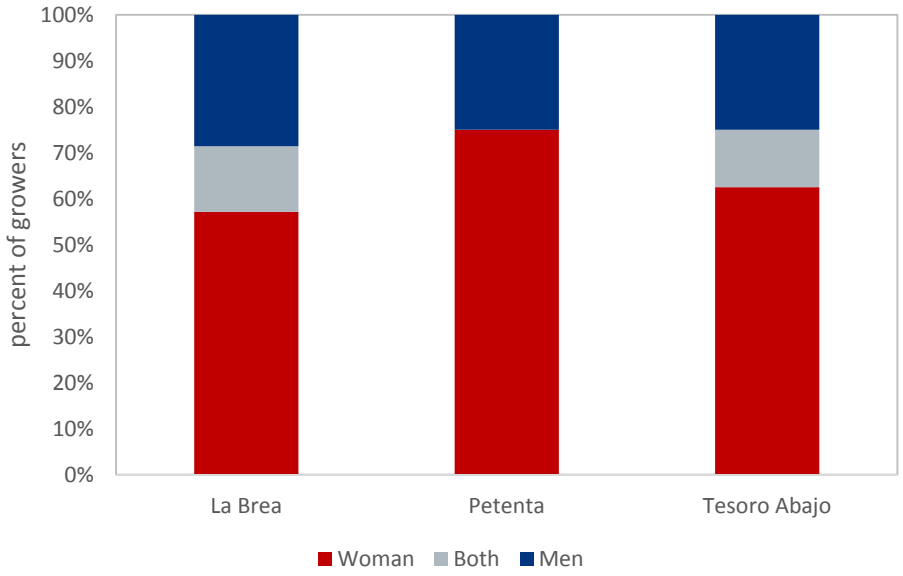

Figure 14. Percent of households reporting gendered management of chaya

Table 27. Germplasm sources of chaya

	All	LaB	Pet	Tes
Family of the same community	13	3	2	8
Neighbor of the same community	5	3	1	1
Donation of government or organization	1			1
Family from another community	1	1		

Table 28. Mean yield of chaya, excl. zeros

	All	LaB	Pet	Tes
Overall Yield (Kg/Ha)	10.9	0.25	19.5	11.3
Estrella	0.5	0.25		0.75
Mansa	14.4		19.5	13.4

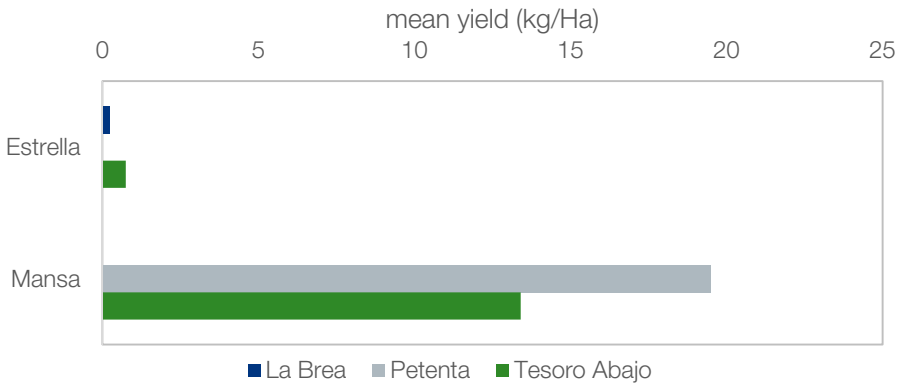

Figure 15. Mean yield of different chaya varieties

Sale of chaya

No household reported selling chaya but three households said they had traded chaya. Two households in Tesoro Abajo and one in Petenta had traded very small amounts of chaya within the community.

Tepary bean and common bean

Tepary bean is being introduced to the communities involved in the project. Its acceptability for being integrated as a drought tolerant bean variety is being assessed. The below analysis describes the state of common bean cultivation in the communities, which may relate to tepary bean, once introduced in the villages.

Cultivation of common bean

The level of cultivation of common bean in the surveyed blocks is shown in Table 29. Approximately half the surveyed households were growing common bean. A lower proportion of households was growing common bean in Petenta than in the other villages. Overall, the farmers allotted a mean 0.6 Ha to common bean, representing about 64% of their total farmland. The area of common bean cultivation was also slightly smaller in Petenta compared to the other two villages.

Table 29. Details on cultivation of common bean in full sample and by region

	All	LaB	Pet	Tes
# of households growing common bean	43	15	11	17
% of households growing common bean	48.9	53.6	35.5	58.6
Mean area devoted to common bean by growers (Ha)	0.6	0.5	0.4	0.9
Mean % of farmland devoted to common bean by growers	64.2	75.8	44.3	74.7

Management of common bean

While chaya was seen to be mainly a womans' crop, the baseline results show that beans are mostly a male managed crop (Figure 16, Table 30).

Table 30. Number of households reporting gendered management of common bean

	All	**LaB**	**Pet**	**Tes**
Woman	4	1	0	3
Men	46	15	11	20
Both	6	0	2	4

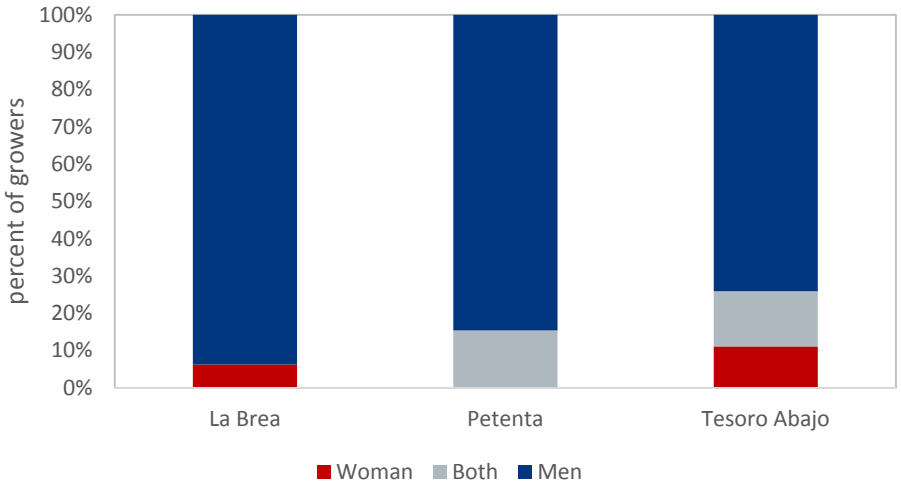

Figure 16. Percent of households reporting gendered management of common bean

Sale of common bean

While approximately half of households were growing common bean, only seven (16%) noted selling it for income (Table 31). Two households had sold it to the market and four sold to their neighbor (Table 32). An additional two households were noted to trade common bean.

Table 31. Number of households selling common bean

	All	LaB	Pet	Tes
# of households selling common bean	7	3		4
% of common bean producers selling production	16.3	20.0		23.5

Table 32. Locations of sale for common bean

	All	LaB	Pet	Tes
Sold at market	2			2
Sold to neighbor	4	2		2

Food security and diet diversity

To asses food security and diet diversity a variety of indicators were applied. In order to understand patterns of food insecurity, the months of adequate household food provisioning (MAHFP) indicator was used in the baseline household survey (Bilinsky and Swindale, 2010). A separate survey in March 2016 was made to asses diet diversity. This survey applied the methodology to calculate a Household Dietary Diversity Score (HDDS; Swindale and Bilinsky 2005). The HDDS results were complemented by a series of questions in the baseline household survey on consumption of different foods during lean and abundant periods of the year.

Food security (access dimension)

Months of adequate household food provisioning

Overall, households in the surveyed villages experienced food shortage for a mean of 4.0 months in the last year. Five of the 88 households (6%) did not experience any month with food shortage in the last year. June was the month with the highest number of households reporting food insecurity (80%; Figure 17). In general, the most food insecure period, when 40-80% of households, had insufficient food was between May and August (Table 33). The lowest number of households experiencing food insufficiency was in October and November but some households experienced food shortages in every month of the year.

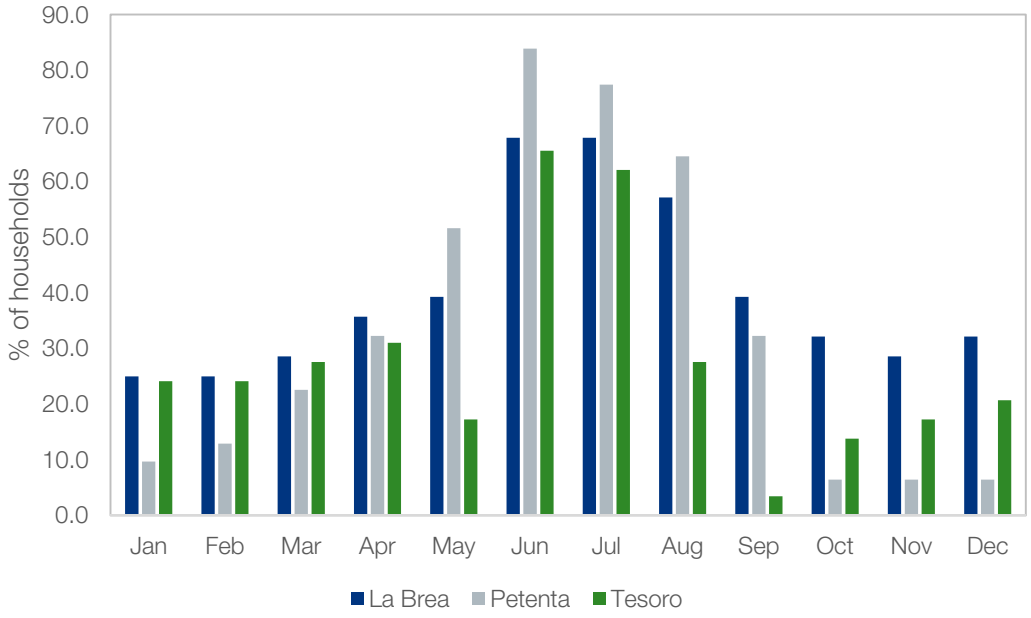

Figure 17. Percentage of households that reported insufficient food consumption by month

Table 33. Number of households reporting insufficient food provisioning by each month of the previous year

	All	LaB	Pet	Tes
January	17	7	3	7
February	18	7	4	7
March	23	8	7	8
April	29	10	10	9
May	32	11	16	5
June	64	19	26	19
July	61	19	24	18
August	44	16	20	8
September	22	11	10	1
October	15	9	2	4
November	15	8	2	5
December	17	9	2	6

Diet Quality

Household Dietary Diversity Score (HDDS)

The Household Dietary Diversity Score (HDDS) is a proxy indicator that is helpful to understand the ability of a household to access a variety of foods (Swindale & Bilinsky 2006). The HDDS is composed by 12 food groups: cereals, white roots and tubers, vegetables, fruits, meat, eggs, fish and seafood, pulses nuts and seeds, dairy, oils and fats, sugar and sweets and spices, condiments and beverages. The respondents are asked how many food groups have been consumed by their household in the past 24 hours. The HDDS score is calculated as the number of food groups consumed, which can range from 0 to 12. Studies have shown that an increase in dietary diversity is correlated to a household's socio-economic and food security level (Hoddinot and Yohannes, 2002; Hatloy et al., 2000).

The mean number of food groups eaten by the households surveyed (HDDS) ranged between 4 and 8. The mean HDDS overall was 5.48±1.07 St. Dev (Table 34). Tesoro Abajo had a slightly higher HDDS than Petentá and La Brea. There are no established cut-off points for the calculation of HDDS, therefore, in order to develop further analysis, the mean of HDDS for the whole sample (5.48) was used as threshold, as suggested by the guidelines (Swindale and Bilinsky 2005).

Table 34. Mean FCS score and number of households within FCS threshold categories

	All	LaB	Pet	Tes
Mean HDDS	5.48	5.33	5.39	5.71
# HDDS >5.48	39	10	13	16
# HDDS <5.48	41	14	15	12

Food groups consumed

Every household surveyed had consumed cereals, pulses nuts and seeds, spices and condiments, and sweets and sugars in the past 24 hours (Figure 18; Table 35). By contrast, white roots and tubers, fish and seafood, meat, and dairy were consumed by less than 10% of households. Oils and fats were consumed by

24% of households, eggs by 54%, and vegetables by 40%. Tesoro Abajo was the village with the highest diversity of food groups consumed, while households in La Brea had consumed the fewest food groups. Households in this latter site had not consumed dairy, fish and seafood, meat, or white roots and tubers. Their only sources of proteins were eggs and pulses, but they had more commonly consumed vegetables than households in the other villages, which provide an important source of micronutrients. Consumption of animal protein was slightly more common in Tesoro Abajo than in Petentá, while the consumption of oils and fats was more common in Petentá than in the other two villages.

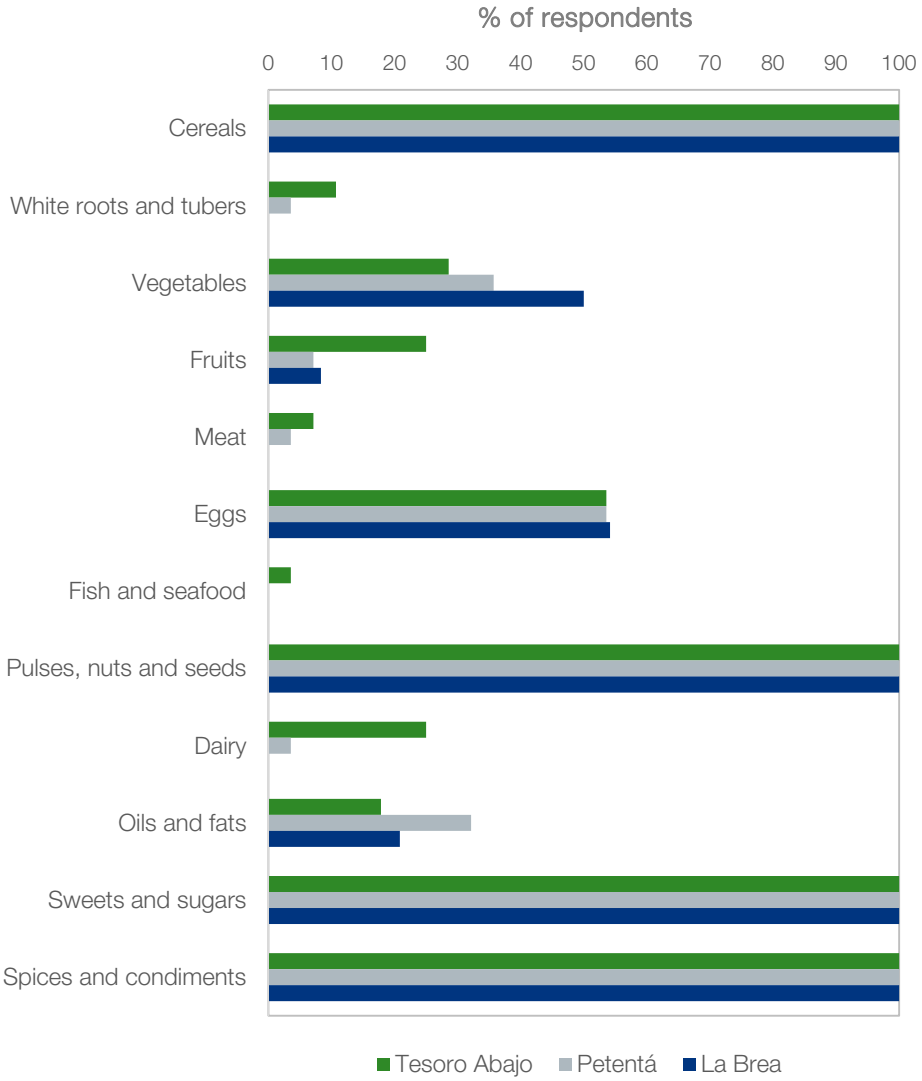

Figure 18. Percentage of households reporting consuming each food group by village

Table 35. Number of the overall sample reported consuming each food group

	All	Tes	Pet	LaB
Cereals	80	28	28	24
White roots and tubers	4	3	1	0
Vegetables	30	8	10	12
Fruits	11	7	2	2
Meat	3	2	1	0
Eggs	43	15	15	13
Fish and seafood	1	1	0	0
Pulses, nuts and seeds	80	28	28	24
Dairy	8	7	1	0
Oils and fats	19	5	9	5
Sweets and sugars	80	28	28	24
Spices and condiments	80	28	28	24

Vegetable, eggs and oils and fats were consumed much more commonly among those with above-average diet diversity (Figure 19). Those with above-average diet diversity were also more likely to consume white roots and tubers, fruits, meat and dairy, which were more rare foods overall.

Table 36. Number of households consuming food groups, for respondents with a below and above average HDDS (mean =5.48)

Food group	All		Tesoro Abajo		Petentá		La Brea	
	>5.48	<5.48	>5.48	<5.48	>5.48	<5.48	>5.48	<5.48
Cereals	39	41	16	12	13	15	10	14
White roots and tubers	3	1	2	1	1	0	0	0
Vegetables	22	8	6	2	8	2	8	4
Fruits	9	2	6	1	1	1	2	0
Meat	3	0	2	0	1	0	0	0
Eggs	32	11	11	4	13	2	8	5
Fish and seafood	1	0	1	0	0	0	0	0
Pulses, nuts and seeds	39	41	16	12	13	15	10	14
Dairy	7	1	6	1	1	0	0	0
Oils and fats	18	1	5	0	9	0	4	1
Sweets and sugars	39	41	16	12	13	15	10	14
Spices and condiments	39	41	16	12	13	15	10	14

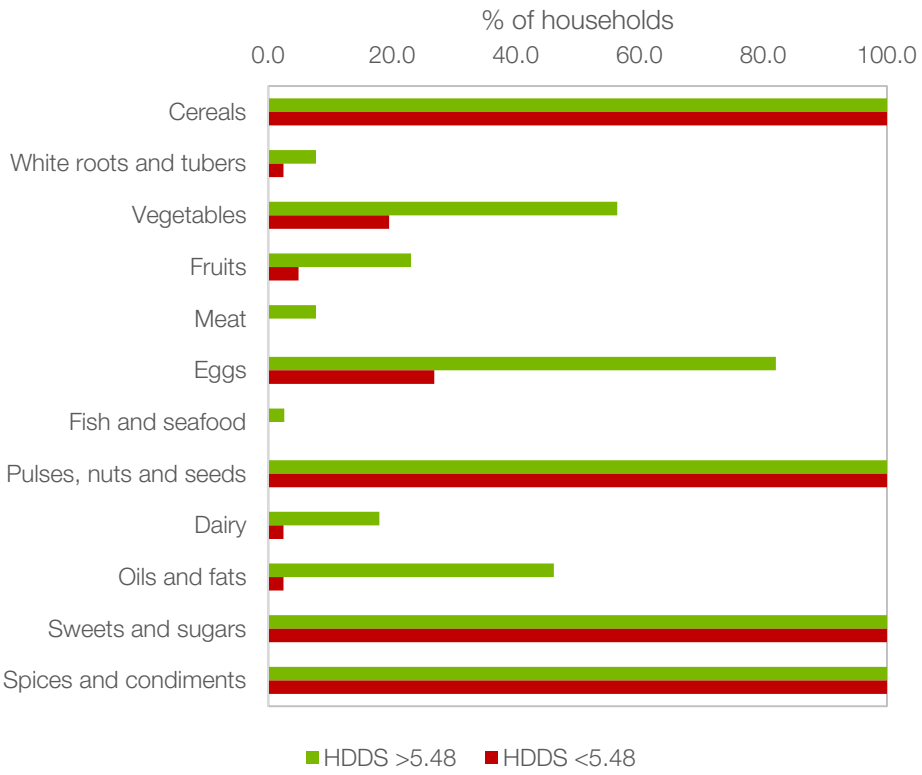

Figure 19. Percentage of households with above and below average HDDS (5.48) reporting consuming each food group by village

Food consumption patterns in lean and abundant seasons

Information regarding the relative frequency of consumption of 12 food groups was collected in the baseline household survey considering critical months (months with food shortages, such as the ones in the lean period) and normal months. The 12 food categories considered were: pulses and nuts, cereals, tubers, vegetables, fruits, meat, fish, eggs, dairy, oils and fats, sugar and sweets and, lastly, beverages. The frequency options were: *muchas veces* (consumed more than 10 times a month, which means more than 3 times a week), *algunas veces*, (consumed once or twice per week), *pocas veces* (consumed once or twice per month) and *nunca* (never consumed).

The results corroborated the findings of the diet diversity survey. Most households were consuming grains, legumes, vegetables, and eggs in the lean season as well as in good periods (Figure 20; Table 37). Fewer housheolds were consuming fish, meat and dairy, and roots and tubers. Roots and tubers, fruits, meat and fish were consumed by more households in the abundant seasons. Consumption of most food groups was less frequent (e.g. 1-2 times per month instead of 1-2 times per week) in the lean season (Figure 21). There was indication of grains being consumed more often in the critical months.

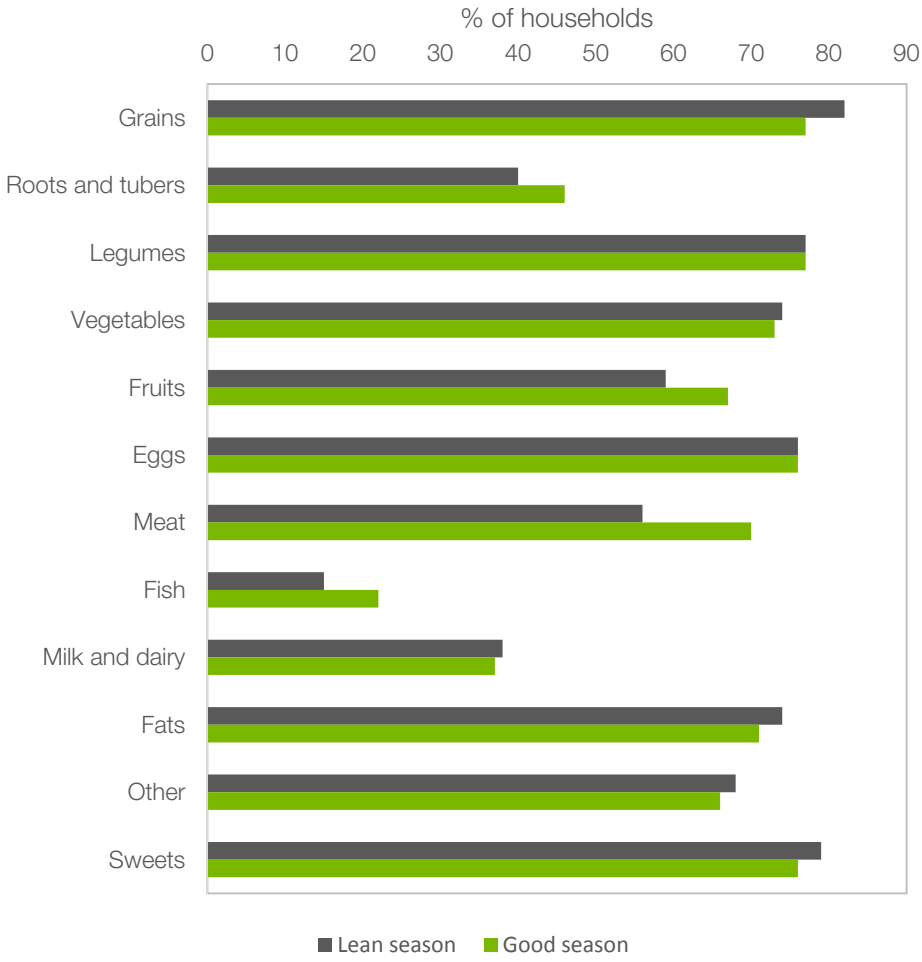

Figure 20. Consumption of food groups in lean and good season

Table 37. Number of households consuming food groups in lean and abundant periods

	Overall		La Brea		Petenta		Tesoro Abajo	
	Lean	Good	Lean	Good	Lean	Good	Lean	Good
Eggs	76	76	23	26	29	27	24	23
Fats	74	71	22	23	29	26	23	22
Fish	15	22	3	5	6	6	6	11
Fruits	59	67	20	24	21	22	18	21
Grains	82	77	28	26	30	27	24	24
Legumes	77	77	25	26	29	27	23	24
Meat	56	70	14	23	21	23	21	24
Dairy	38	37	9	7	10	9	19	21
Other	68	66	25	24	23	21	20	21
Roots & tubers	40	46	12	14	12	15	16	17
Sweets	79	76	26	26	30	27	23	23
Vegetables	74	73	24	25	28	25	22	23

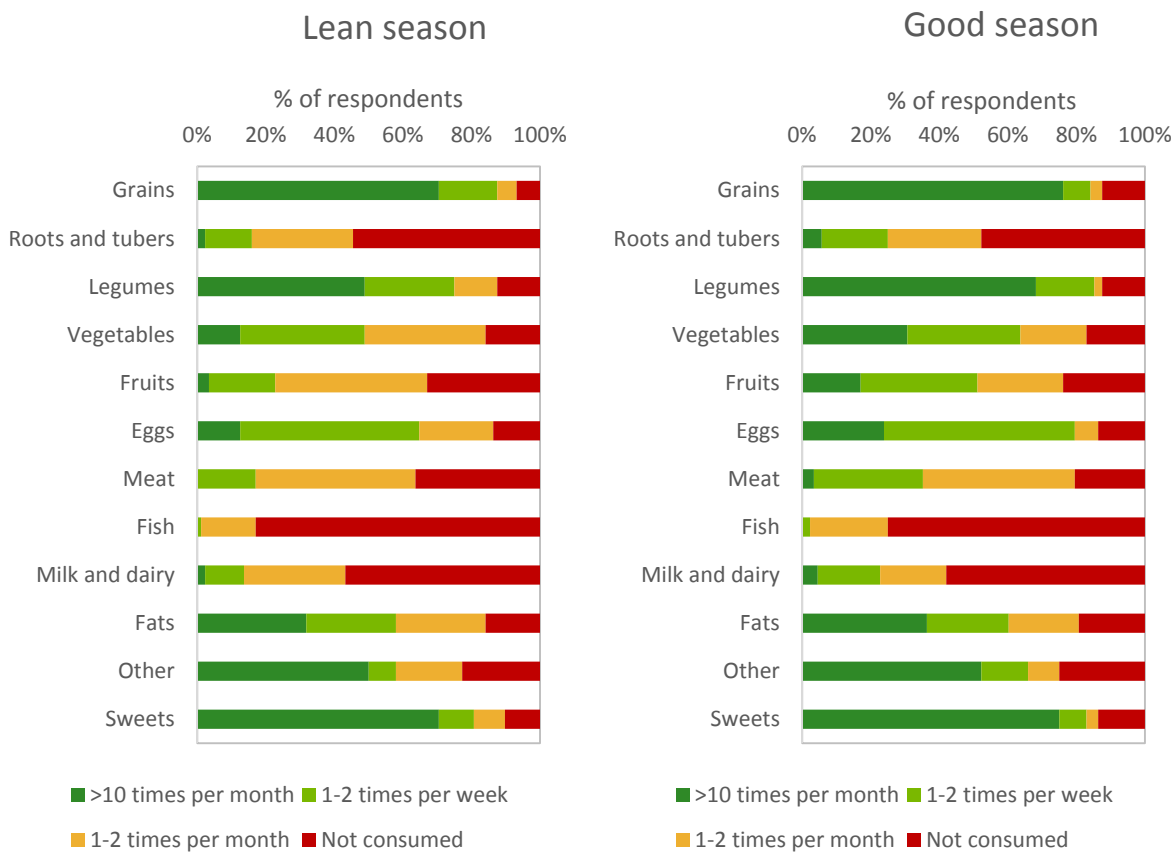

Figure 21. Consumption frequency of foods in lean and abundant periods

Synthesis and closing remarks

The farmers in the three villages included in this study have integrated crop and livestock farming systems for a mix of subsistence and market production. Households maintained a mean of 1.5 livestock species and 2.8 crop species, meanwhile five species of livestock and 25 crop species were documented across the communities. Crops and livestock were vital for subsistence. Few households were earning income from their crop (16%) or animal (8%) production. Farm labour positions outside the community were a prominent income source for the communities (9% of households). The primary crops grown by the most households and in largest areas were maize and common bean. A diversity of vegetables and fruit species were cultivated across the communities, many of which were native to the Mesoamerican region.

Chaya

Chaya was the most common vegetable that was documented in the sites—grown by 31% of households. The fact that the survey explicity asked about chaya production may contribute to the higher frequencies of cultivation documented in the survey relative other vegetables. Two varieties of chaya were cultivated in the surveyed communities. Most households kept one variety but a few kept two varieties. The most popular variety was mansa. The estrella variety was grown in lower frequency. The mansa variety appeared to give the highest yields but it is noted that there were many assumptions made in calculating the area and mass of harvest, as different units were used for yield and area between households. It was also unclear the time period for which the yield data referred to, as chaya can be harvested year round. Further investigation into yield of chaya should be carried out. Chaya was used exclusively for household consumption. Three households were noted to trade chaya within the village but no household was noted to be selling chaya in the market.

Tepary bean

Tepary bean was not cultivated by any of the surveyed households. Around half of households (49%) were growing common bean and it was grown in large areas relative other crops (mean 0.9 Ha). Whereas chaya was seen to be managed mainly by women, beans were managed almost exclusively by men. Sixteen percent of common bean producers were earning an income from their production.

Underutilized crops in diet diversity and food security

The households surveyed experienced food shortage for on average four months in the previous year. May to August was the peak period of food insecurity, which corresponds to the period during the first rainy season and the ‘canicula’, before the first harvest. In the 24 hour recall survey performed in March, households had eaten a mean of 5.5 food groups. Every household had consumed cereals, pulses, nuts and seeds, spices and condiments, and sweets and sugars. Fewer households had consumed white roots and tubers, fish and seafood, meat, dairy, eggs, and vegetables. Some food groups like meat, fish, fruit, and roots and tubers, and vegetables were consumed by more households and more frequently in the abundant period than in the lean season.

Chaya stood out as a crop that can help enhance consumption of vegetables—especially in the lean period, as it is a perennial crop. There were many other native vegetables and fruits documented in the household survey that could have a role in increasing availability and consumption of these foods for more balanced diets. Native vegetables documented included chipilin, hierba mora, guisquil, loroco, and dante. Native fruits documented in the survey were mamey and zapote. Other native vegetables and fruits exist in Guatemala (e.g. Azurdia 2016; Box 1) which could also be grown locally and important in supporting better food security and nutrition.

Only two species of cereals were documented in the production survey. Maize dominated production, while just a few households were growing sorghum. Other cereals and roots and tubers could be relevant for diversifiying the production of starchy foods. Similarly, only one species of legume was documented in the production survey. In this sense, tepary bean can be key in building more resilient supply of pulses for the communities.

Conclusions

This baseline household assessment provided an overview of the production and livelihood systems of three communities in Chiquimula, Guatemala which are being targeted with activities to increase the cultivation, commercilaization and use of chaya, tepary bean and other underutilized speices to improve nutrition and climate resilience. The survey documented the level of cultivation, commericalization and consumption of these crops prior to the interventions. The study also revealed how these species contribute to the livelihoods of the surveyed communities and the roles they could have in further improving food security, nutrition, and incomes. Chaya stood out as a crop that can support increased vegetable availability and consumption, especially in the lean season. Tepary bean can play a key role in diversifying the portfolio of pulses for better climate change resilience.

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